The Northwestern MILLER
MILLING PRODUCTION SECTION

Possible Uses of Air Classification And Impact Reduction in the Milling Process

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DURING the past century the gradual break and reduction system using the roller mill, sifter and sieve purifier has been used in the milling industry. Recently pneumatic conveying and air classification of the milled flour product have refined the milling process without altering its basic nature. The studies described here were undertaken to determine whether different grinding techniques, such as impaction, might prove useful in milling. The possibility of using air classifiers for hard wheats and within the milling process rather than on the end product was also examined.

EDITOR'S NOTE: This is a report of work done under contract with the U.S. Department of Agriculture and authorized by the Research and Marketing Act of 1946. The contract was supervised by the Northern Utilization Research and Development Division of the Agricultural Research Service, USDA, Peoria, Ill.

CHARACTERIZATION OF MILL STOCK

To characterize the properties of stock in a conventional mill flow and to provide reference information to compare with any future mill system, samples of a hard red winter wheat (variety Ponca, 1.4% ash, 12.8% protein) were milled to three stages in the milling system. The entire stock was removed after breaks, sizings or 2nd middlings reduction, and classified, using Tyler sieves by the procedure of Wichser and Shellenberger (4). The separations were analyzed for protein, ash and moisture content. The relation of protein and ash content to particle size distribution is shown in Figure 1.

The results demonstrate the effectiveness of the present milling system in separating high and low ash stock by successive roll reductions and sieve classifications. Throughout the conventional milling system there is a positive correlation between ash content and particle size. A sharp increase in ash content was noted after breaking and sizings in stock larger than 600 microns, and after 2nd middlings in stock larger than 200 microns diameter. When the same wheat was ground on a Wiley mill, an even distribution of ash over the entire size range was noted.

A slight increase in protein content in the finest and coarsest fractions was noted after breaks and sizings reductions. After 2nd middlings reduction, protein content varied directly with particle size. The present milling system is not effectively separating on the basis of protein content. Should high protein stock be desired, it might be better to make these classifications after break and sizings reductions rather than on the end product.

AIR CLASSIFICATION OF REPRESENTATIVE FLOUR STREAMS

Granulation studies of different wheat flours showed that the chemical and baking properties of flour material varied with particle size (4, 5). Morris, Alexander, and Pascoe (3) indicate that endosperm from different zones of the wheat kernel have different relative amounts of protein and ash content. An air classifier can separate fractions relatively high in protein, and

(Turn to POSSIBLE USES, page 4a)

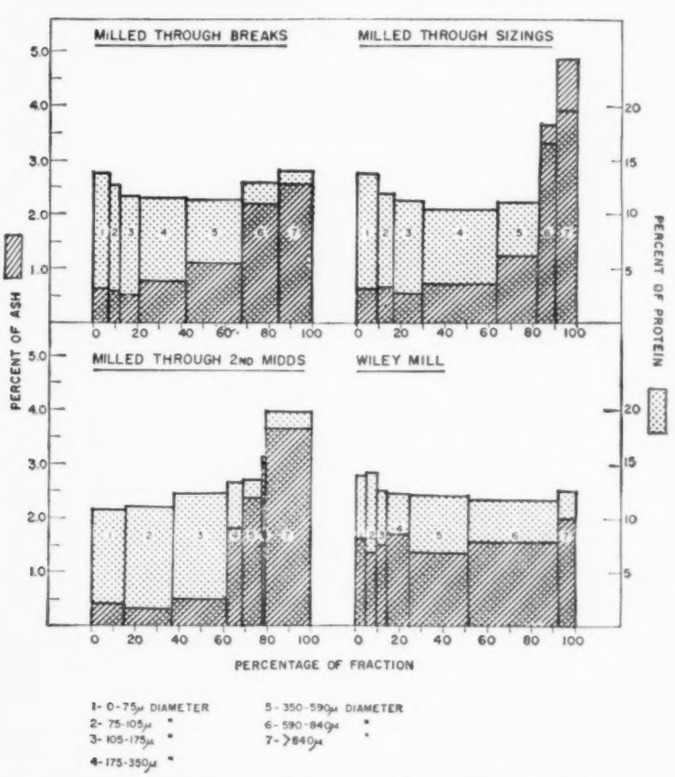


FIGURE 1—Interrelationship between ash content, protein content, and particle size distribution of milled stock at three stages of milling, and of ground wheat.

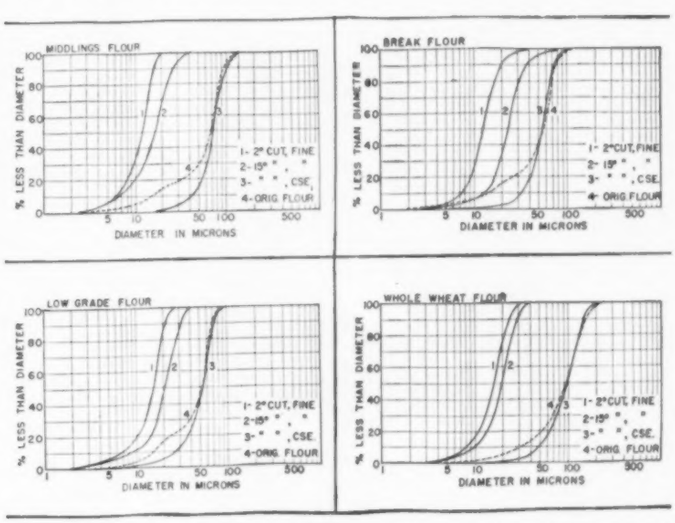
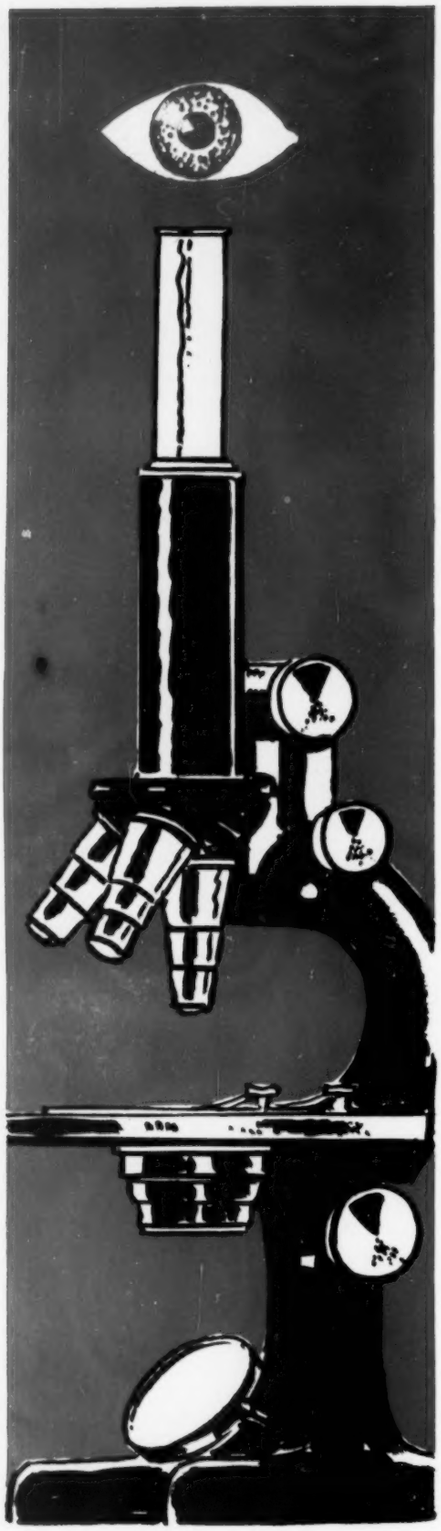


FIGURE 2—Particle size distribution curves of separations from four hard red winter flour streams using 2° and 15° air vanes.



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New Development in Custom Grain Fumigation

By Carl Dawson

EDITOR'S NOTE: Mr. Dawson is president of Ferguson Fumigants, Inc., Hazelwood, Mo.

GREAT changes have been taking place in recent years in the practice of grain fumigation. Until only a few years ago, nearly all fumigation of grain was performed with carbon tetrachloride base fumigant mixtures—either applied to the surface of the grain or added to the grain as it was binned.

The introduction of flat storage for grain with perforated ducts on the floor, connected to a fan in such a manner as to pull the air down through the grain for purposes of cooling and conditioning the grain has made possible the use of such fumigants as methyl bromide, ethylene dibromide-methyl bromide mixtures, hydrocyanic acid gas and chloropicrin. These fumigants had hitherto been considered primarily for space fumigation of food processing establishments, flour mills and warehouses containing package foods.

Here is an over-all view of the portable connection between the aeration fan outlet and the space above the grain that was developed so that every fumigation could be a recirculation fumigation.

These fumigants are introduced into the air space above the grain and pulled down through the grain until they begin to come out of the aeration fan; or, the aeration fan is re-wired to reverse its direction to permit fumigants to be introduced into the fan duct; or, in some cases a combination of both the push-up and the pull-down method is employed. In some sections, particularly in the South, it was discovered that if the outlet of the aeration fan could be connected through the upper bin wall or the roof, into the air space above the grain and the fumigant-air mixture passed through the grain several times, more complete and even distribution could be accomplished with the accompanying more complete and even insect kill.

Problem Stated

These fumigants have been available only in steel cylinders of relatively small size. Steel cylinders have presented some serious problems in properly carrying out these fumigations, especially those fumigations which are commonly called "single pass fumigations" as distinguished from "recirculation fumigations" in which the built-in return duct is employed.

It is important that the gas be supplied into the air moving through the grain at a rate that will permit the total dosage application during the time required for a single pass of the air through the grain. If the dosage is applied at a greater or a lesser rate, it is likely to have an adverse effect upon the fumigation results. If the rate of application is too fast, then fresh air free of fumigant is pulled down into the grain before the fumigant-air mixture has reached the bottom and begins to come out of the fan. If it is too slow, then considerable fumigant must be lost from the bin by blowing it out before the last of the fumigant has been introduced into the system.

Cylinders are automatically regulated as to their rate of release of the fumigant by maximum rate of flow allowed by the cylinder valve with which they are equipped. Oftentimes the same valve is used on small and large size cylinders and it has been observed that these valves do not always have the same rate of flow. Dependence upon the rate of flow of cylinder valves for the speed of fumigant release has proven to be highly undependable.

Ferguson Solution

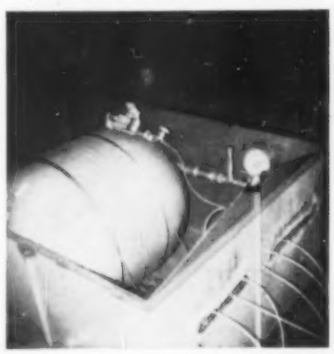
Ferguson Fumigants, Inc., Hazelwood, Mo., believes it has solved these major problems for the custom fumigator. The problem of rate of application encountered with the cylinders has been solved by the elimination of cylinder distribution. The use of these fumigants in grains has reached multi-million pounds a year volume that lends itself to bulk distribution. Ferguson Fumigants' particular fumigant mixture, known as Dawson 37 fumigant, is a mixture of 30% ethylene dibromide-70% methyl bromide, by weight, and has a strong, distinctive odor, obnoxious in high concentrations.

This strong odor is most valuable from a safety point of view, in connection with transportation in bulk. An extensive program of testing revealed that by changing some of the component parts in commercially available valves and meters, they can be adapted for use with the fumigant. Details of the results of these investigations were presented to the Interstate Commerce Commission and a special permit was issued for the development of a tank-truck semi-trailer for the transportation of this fumigant mixture. This trailer was first put into use in transporting the methyl bromide-ethylene dibromide mixture to Ferguson Fumigants' Hazelwood plant where a successful transfer system to storage tank was developed.

The next problem was getting the fumigant to the fumigation job in bulk, and solving the problem of metering it into the grain bin at a known rate of flow. A small fumigation tank was developed that could be mounted on a small truck, or trailer, from which the liquid fumigant passed a meter into a valve header with multiple outlets. A portable, light weight hose can be attached to these outlets and extended into the bin to proper locations for good vapor distribution. At the end of this hose there has been developed a nozzle with exchangeable orifice sizes for which there is a known rate of flow ratings. By this means the fumigator can control the amount of fumigant applied and the rate at which it is applied—which can be coordinated with the rate of passage of the air through the grain.

The remaining problem was to develop a portable connection between

(Turn to FUMIGATION, page 18a)



Here is the small fumigation tank that was developed from which the liquid is passed through a meter into a valve header with multiple outlets.

Role of Wheat in Improving Nutritional Status, Labor Productivity in Lesser Developed Countries

By Helen Farnsworth

IT IS often asserted that American grants and concessional sales of surplus wheat have relieved serious undernourishment and raised labor productivity in recipient underdeveloped countries. Moreover, the recipient countries are pictured as areas where large masses of the people are chronically hungry and seriously underfed. To most Americans, this humanitarian view of our surplus wheat exports is most encouraging. If correct, it would presumably hold important implications for American agricultural and foreign aid policies.

One basic question, however, needs to be answered: what assumptions and factual evidence underlie these heart-warming assertions? This is the question inevitably asked by scientifically-minded economists, by hard-headed members of the U.S. Congress, and by representatives of competing exporting nations who fear that the heavily subsidized American exports have substantially curtailed "commercial" wheat exports from their own countries. It is this question that I propose to discuss.

I. Conditions Requisite to Relief of Undernourishment Through Exports of Surplus Wheat

Logical analysis indicates that at least four basic conditions must exist if concessional exports of surplus wheat are effectively to relieve serious undernourishment and perhaps increase labor productivity in any given underdeveloped country.

First, wheat must be a useful food—in the processed forms consumed, it must contain nutrients needed for human life and activity.

Second, the concessionally priced export wheat must fill a conspicuous dietary need that would remain unfilled in the absence of special wheat-export concessions.

Third, the imported wheat (or its nutritive equivalent in other foods) must be channeled to and consumed by the particular population groups in the nation whose diets would otherwise be seriously deficient.

Fourth, if, in the recipient country, the projected improvement in nutritional status is to be maintained in later years without hazardous dependence on continued foreign export subsidies and foreign exchange concessions, there must be concurrent per capita expansion of domestic production—either production of similarly nutritive foods or, alternatively, production of exportable products that can be traded for food imports.

Now, let's consider whether, and to what extent, the available evidence suggests that the first three of these conditions actually exist. The fourth point I shall barely mention. It opens up complex questions as to the effectiveness of economic planning and programs in the underdeveloped countries, as well as to the probable contribution of American surplus wheat to economic development.

EDITOR'S NOTE: The author is an economist and professor with the food research institute at Stanford University. This paper was originally published in the International Wheat Surplus Conference Proceedings.

If trustworthy evidence indicates that the first three conditions exist, we can look hopefully on proposals

(Turn to ROLE OF WHEAT, page 9a)

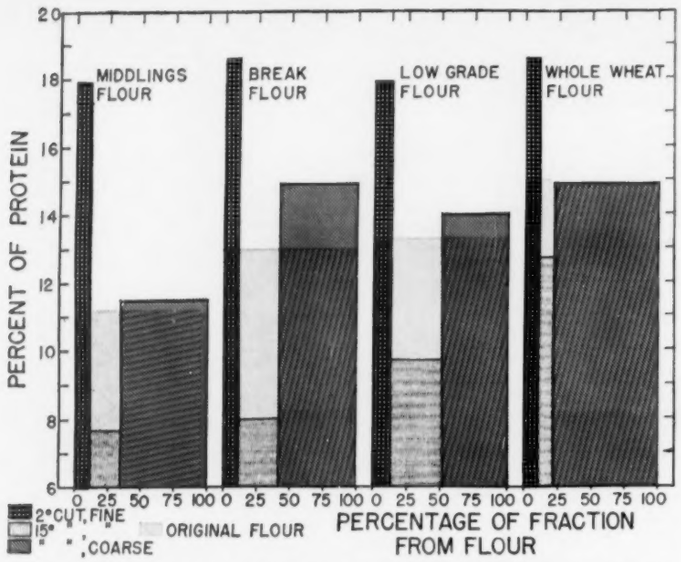


FIGURE 3—Relationship between protein content and particle size distribution of air classified separations from four hard red winter flour streams.

POSSIBLE USES

(Continued from page 1a)

having less than 20 microns diameter, and fractions low in protein between 15 and 30 microns in diameter. These finer fractions are considered to be "free" gluten and starch cells. Air classifiers are being used with soft wheat and some lower quality hard wheats to remove not only fractions which are acceptable for blending into bread flours but also fractions which can be used in cake flours. This study was designed to examine and compare the chemical, physical dough and baking properties of hard wheat flour streams classified into high and low protein fractions.

Four representative hard winter flour streams (2nd middlings flour, 2nd break flour, 1st low grade flour, whole wheat flour) and a straight grade flour were classified into high protein, low protein, and coarse fractions using a Sharples air classifier (2) at 2° and 15° air angle settings. Particle size analyses of the fractions separated by means of a Sharples Micromerograph (Figure 2), and protein determinations of the streams (Figure 3) showed that a good separation of high and low protein fractions is possible from hard wheat flours as well as from soft wheat flours. Protein separations were most effective with middling and break flour streams.

To provide a rough index of starch damage, gas production analyses of 10 gm. samples of the separations were determined by using 0.01 gm. Rhozyme 33 per 100 ml. water to provide an excess of alpha amylase. The high and low protein separations had higher gas production (Table I) indicating many broken starch granules even in the high protein fraction. Farinograms of the separations revealed (Table I) that the high protein fractions had highest absorption and unusually long mixing time, while the low protein fractions had shortest mixing times and lowest absorptions. Dough properties of the coarse separations were similar to those of the original flours.

Loaves baked from the various separations (Figure 4) showed that in all cases, the original flour and coarse fractions had best baking quality. The low protein fractions produced the poorest quality loaves. Although the high protein fractions separated from the middlings flour produced loaves of good volume, their quality was inferior to loaves baked from the original flour. Only the high protein fraction from break flour had a bread quality score equal to the original flour. Cake baking tests showed that, while the low protein fractions, after bleaching, produced better cakes than the original flour streams, none of the samples baked approached the quality of soft wheat cake flour.

Since the high protein separations from the various flour streams were mostly unacceptable in themselves as bread flours, their blending value to improve loaf volume of weaker flours was examined. The high protein fractions were mixed with a lower protein (10.6%) family flour to protein levels of 14% and 16% and baked. Notable increases in flour absorption and final loaf volume, but with no loss in baking quality, resulted from protein supplementation with high protein fractions from

Table I. Chemical, Physical Dough and Baking Properties of Flour Fractions Separated With a Centrifugal Air Classifier.

Flour Source	Cut	Percent of Total Product	Protein (%)*	Farinograph Absorption (%)*	Farinograph Mixing Time (min.)	Gas Production (mm. of Hg)*	Bread Score
Middlings Flour	Unclassified	100	12.2	62.3	5.0	294	82
	2° Fines	11.3	17.9	86.7	14.5	395	67
	15° Fines	23.4	7.7	59.0	2.0	603	47
	Coarse	65.3	11.5	59.0	5.0	402	82
Break Flour	Unclassified	100	13.0	63.4	5.0	391	87
	2° Fines	11.9	18.6	83.0	18.5	510	89
	15° Fines	28.6	8.0	56.2	2.5	475	65
	Coarse	59.5	14.9	65.3	7.0	282	92
Low Grade Flour	Unclassified	100	13.3	66.9	5.0	559	74
	2° Fines	12.8	17.9	84.7	8.5	696	54
	15° Fines	25.6	9.7	64.0	4.5	650	45
	Coarse	61.6	14.0	70.2	5.5	334	72
Whole Wheat Flour	Unclassified	100	15.0	71.3	4.5	548	53
	2° Fines	8.3	18.6	89.6	7.5	851	6
	15° Fines	12.6	12.7	70.8	5.5	834	11
	Coarse	79.1	14.9	71.0	5.0	465	48
Straight Grade Flour	Unclassified	100	13.2	76.0	8.0	-	88
	2° Fines	8.7	16.4	83.5	13.0	-	70
	15° Fines	19.4	9.9	64.7	1.0	-	61
	Coarse	71.9	13.7	59.9	4.0	-	91

* 14% moisture basis
* gas produced from 10 gm flour in 5 hours.

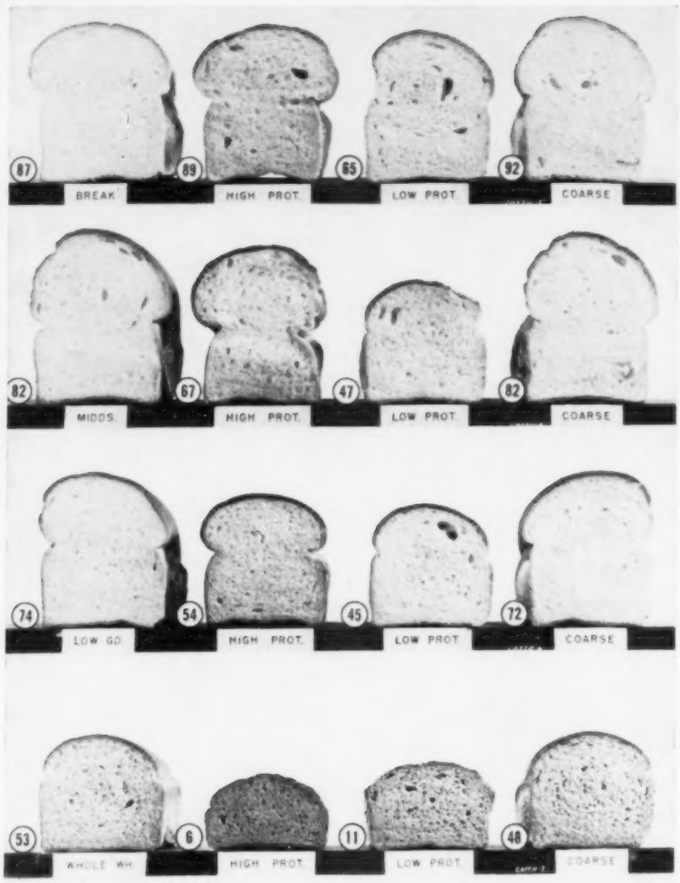


FIGURE 4—Comparison of loaves baked from air classified separations from four hard red winter flour streams. (Bread quality scores appear circled at left of each loaf.)

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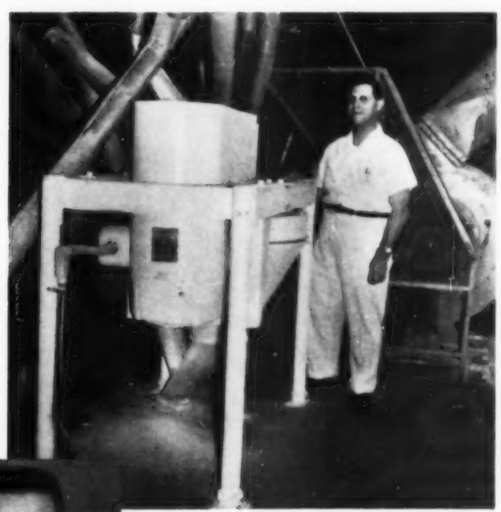

▲ Arthur W. Gust, of DCA Food Industries, shown with the recently installed 27" Entoleter Impact Mill that has increased DCA's capacity and lowered costs.

◀ Marvin D. Jackson, Milling Supt., D.C.A. Industries, Baltimore, Md.

DCA FOOD INDUSTRIES SOLVES A PROBLEM

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break flour (Figure 5). Mixes prepared from high protein fractions of straight grade flour with the family flour, produced loaves inferior in quality to loaves from unsupplemented family flour. It appears that the high protein fine fractions from different flour streams vary considerably in their baking properties. Further study of the baking properties of high protein fractions from different flour streams and different zones in the wheat kernel could indicate which streams would be desirable for use as loaf volume boosters for poorer flours. Apparently, to use air classification effectively for preparation of high protein supplements, certain flour streams should be eliminated and classification should be made not on the end flour product but on certain composite streams.

In most commercial mills, when smooth rolls are used, from 50 to 60% of the roll surface is devoted to reduction of middlings and other stock to the particle size range found in flour. Since the nature of impact grinding is different from roll grinding (1), it is conceivable that the reduction process could be simplified by using high capacity impact grinding machines.

To explore the behavior of middlings to impact grinding, six lots of hard winter wheat middlings (.52% ash, 11.3% protein) were ground on smooth Allis rolls, 27" and 40" diameter Entoleter impact machines and on the Entoleter "Contro Mill." Samples were ground in the following manner:

Code and Treatment	% Through 150 Tyler sieve
1. 40" Ent.—1 Pass Through 4" Entoleter once	30
2. 27" Ent.—6 Passes Through 27" Entoleter 6 times..	47
3. 40" Ent.—6 Passes Through 40" Entoleter 6 times..	82
4. Rolls—1 Pass Through Allis smooth rolls once..	30
5. Rolls—6 Passes Through Allis smooth rolls 6 times	85
6. Contro Mill Through Contro mill once	100

FIGURE 5—Comparison of loaves baked from mixes of a low protein family flour supplemented to 14% and 16% protein content with fine high protein fractions from four flour streams. Loaf score (max. 100) and volume (cc.) follow description of each loaf: Top row: Unsupplemented family flour (84-825); family flour supplemented to 16% protein with fines from middlings (75-960); break (81-975), and straight grade flour (72-755). Bottom row: Family flour supplemented to 14% protein with fines from low grade (81-825); middlings (78-915); bread (82-945), and straight grade flour (69-745).

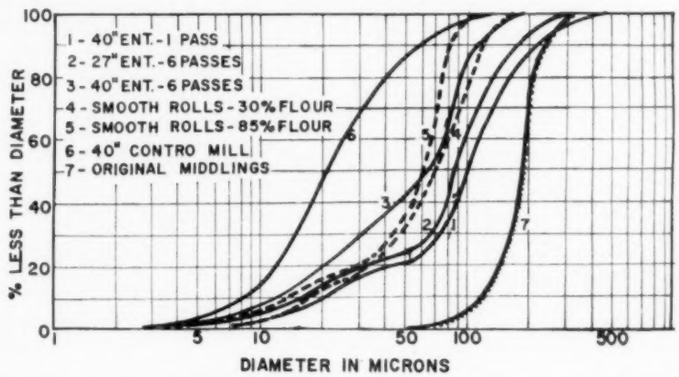

FIGURE 6—Particle size distribution curves of hard red wheat middlings reduced by various impaction and roller mill reduction treatments.

The stock was air classified at the following air angle settings, removing the fines after each separation: 2°, 15°, 25°, 40° (separations of particles at approximately 25, 40, 80 and 125 microns diameter, respectively).

Multiple passes through the 40" Entoleter reduced the particle size over the entire size range (Figure 6, curves 1 and 3), while multiple passes through smooth rolls reduced the size of the coarser particles but not those particles less than 50 microns diameter (curves 4 and 5). Protein values of the finest separations also reflected this difference in grinding (Table II): multiple passes through a 40" impact grinder increased the protein content of the fines, while multiple passes on roller mills did not change the protein level of the fines.

Physical dough tests (Table II) of the finest fraction (less than 20 microns diameter) of samples of similar size distribution (40" Ent.—six passes, and rolls—six passes) revealed that the impact milled stock, with high protein content, had a dough of longer mixing time than the roller milled stock, despite the equally high water absorption of both samples. Since both fractured starch and fine gluten particles increase flour absorption, the fines fraction from impact milled middlings apparently had more fine gluten which lengthens mixing time and less frac-

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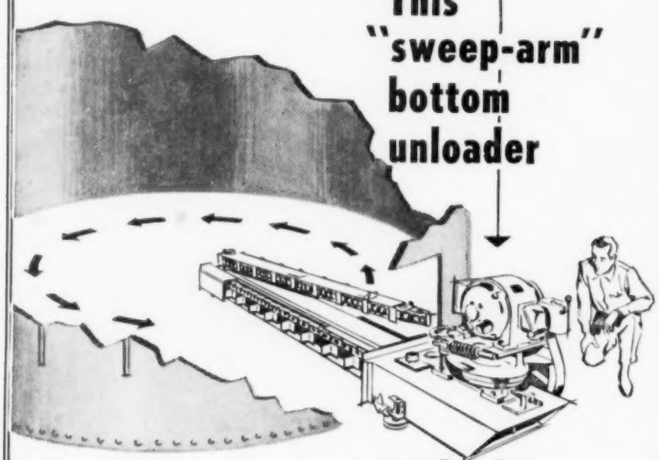

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tured starch than the roller milled middlings.

Loaves baked from air classified separations (Figure 7) showed marked differences in quality and size within the same size range. Loaves baked from impact milled middlings (40" Ent.—six passes) were superior in baking quality to samples reduced with smooth rolls. The degree of impaction is an important factor for baking quality: samples with less severe impaction (40" Ent. —one pass) and over-ground (Contro Mill) samples yielded fractions inferior in baking properties to those with optimum impact grinding (40" Ent.—six passes).

Significantly different physical and baking properties can be obtained from the same material by using grinding techniques of different intensity and nature. It may be possible to improve the baking quality of flour from middlings by impact reduction instead of roll grinding.

RECOMMENDATIONS FOR FUTURE MILLING

The milling industry should re-examine its milling process and consider the possibility of using air classifiers and impact grinders instead of many of the rolls and sieves presently employed. Air classifiers are capable of making separations of fine material much more efficiently and rapidly than sifters, particularly in the size range less than 100 microns diameter. Impact grinders might well replace certain smooth rolls in the reduction process permitting greater capacity with less milling machinery. It may also be possible to improve the baking quality of the flour by impact reduction. A flour mill using pre-break impact grinders, the conventional break rolls and a sim-

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Table II. Chemical, Physical Dough and Baking Properties of Hard Wheat Middlings Separated with a Centrifugal Air Classifier after Various Reduction Treatments.

Treatment	Cut Degrees	% of Total Product	Protein %	Dough Absorption %	Dough Mixing Time (min.)	Bread Score (100)
40" Ent-1 Pass	2	6.6	11.8	71.8	9	59
	15	9.2	7.5	58.1	2	57
	25	6.7	10.8	63.3	3	73
	40	24.2	12.1	60.9	6	79
	Coarse	53.3	12.3	55.1	6	79
27" Ent-6 Passes	2	5.8	11.9	77.2	10	49
	15	13.2	7.6	61.8	2	54
	25	7.4	10.6	64.8	2	72
	40	25.0	12.1	63.2	7	83
	Coarse	48.5	11.8	62.0	5	80
40" Ent-6 Passes	2	12.3	15.5	81.9	11	66
	15	16.9	7.4	59.7	2	64
	25	20.0	10.5	60.5	3	81
	40	26.1	12.1	61.4	4	84
	Coarse	24.6	11.7	60.8	4	84
Rolls-1 Pass	2	16.3	11.7	78.0	4	57
	15	9.3	8.5	68.2	2	39
	25	27.1	11.3	66.7	2	72
	40	31.0	11.6	66.4	4	75
	Coarse	16.3	11.1	62.0	4	65
Rolls-6 Passes	2	15.1	11.8	77.2	4	47
	15	9.3	8.9	68.0	2	49
	25	31.4	10.9	64.3	2	77
	40	33.7	12.1	66.2	3	73
	Coarse	10.5	11.0	68.0	4	59
Contr.Mill-1 Pass	2	38.1	16.7	73.0	19	40
	15	22.2	7.4	61.2	5	25
	25	19.0	10.3	60.6	5	50
	40	15.9	12.3	63.0	4	37
	Coarse	4.8	11.7	66.4	10	10

* 14% Moisture Basis.

plified impact reduction and sieve, plus an air classification system is conceivable. Industrial technology has made amazing strides in the past half century. The future flour mill could also reflect some of these amazing technological improvements.

ACKNOWLEDGEMENTS

The invaluable cooperation of the research laboratories and personnel of the Sharples Corp., Philadelphia; Entoleter Division, Safety Industries, Inc., New Haven, Conn., and Northern Utilization Research and Development Division, USDA, Peoria, Ill., is gratefully acknowledged.

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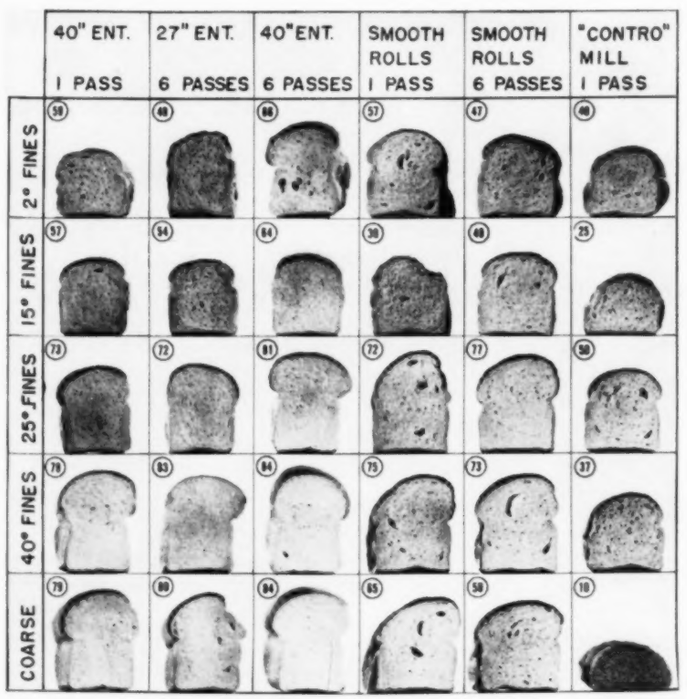


FIGURE 7—Comparison of loaves baked from air classified separations from impacted and roller milled hard wheat middlings. (Bread quality scores appear circled at upper left of each loaf.)

ROLE OF WHEAT

(Continued from page 3a)

for continued heavy exportation of surplus wheat on concessional terms. If the evidence appears to point the other way, even with respect to one of these prerequisite conditions, we must be prepared to adjust our thinking toward suitable modification of recent wheat surplus disposal programs.

For centuries wheat has been the basic food staple of Western Europe and of European settlements elsewhere. As levels of living have advanced in these areas over the past century, bringing a wider variety of foods to consumers at moderate cost, the dietary role of wheat has substantially declined. Yet even in the U.S. (where the decline has been most marked) wheat products still furnish roughly a fifth of the total calories and a fifth of the total protein in the national food supply; and they also account for 15 to 30% of each of the several major B vitamins and iron. Admittedly, the latter figures overstate the contribution of wheat alone, since they are materially raised by the customary enrichment of wheat flour and by other elements (notably milk) used in baking American breads. Nevertheless, the adjusted data for wheat alone would remain impressive.

Still more impressive in their implications for the kinds of diets found in less developed countries are the British Medical Council's records of the Wuppertal experiments in feeding wheat bread to undernourished German children after World War II.

The basic objective of these experiments was to find out as much as possible about the nutritional value of different types of bread as the primary food in diets more limited than usual in animal proteins and fats. Four major types of wheat bread were used in the experiments: unenriched white bread made of 70% extraction flour; white bread enriched with thiamine, nicotinic acid, riboflavin, and iron; wheat bread of 85% extraction, and whole wheat bread. With other foods restricted by rationing, the undernourished children ate so much of the unlimited bread (made solely from flour, water, yeast and salt) that this food constituted roughly 75% of their average diet; the remainder consisted mainly of potatoes, other vegetables, and soups, with a minor daily supplement of less than half a cup of milk. The total animal protein averaged only eight grams a day (including the milk). On this diet, regardless of the type of bread eaten, the undernourished children made rapid physiological recovery during the 12 months of observation.

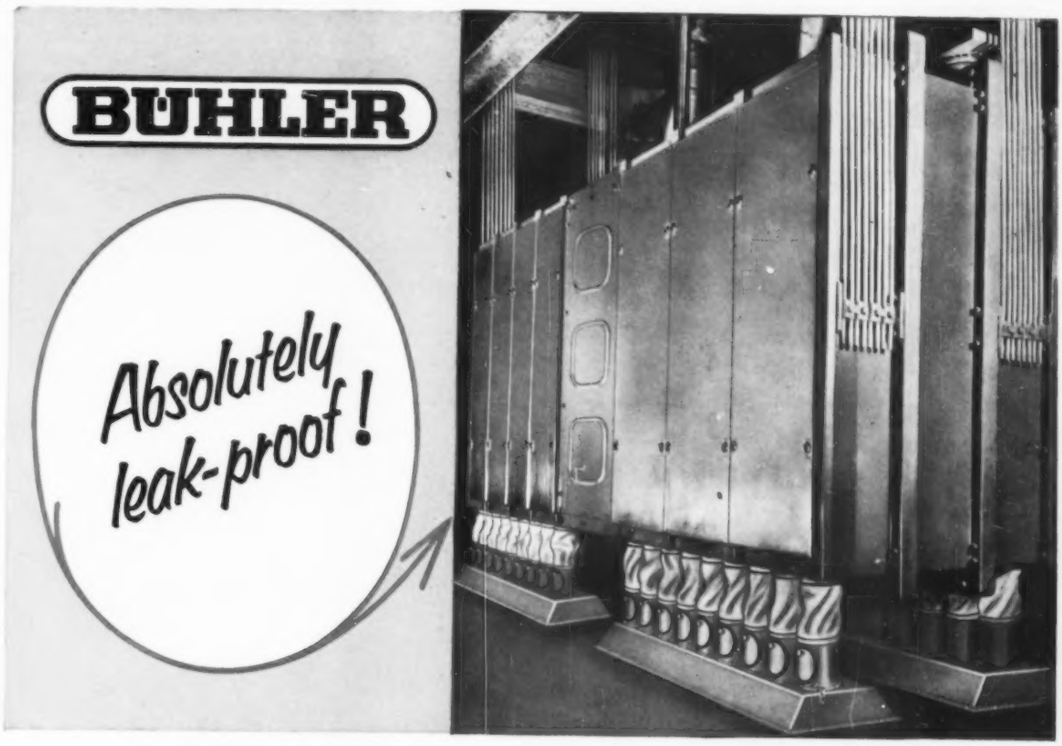
At the end of the year, 134 of the children participated in a second dietary study, designed to determine whether extra milk (over a pint a day) would bring forth a better clinical response than an equivalent number of calories in the form of cookies made from 85%-extraction wheat flour, margarine, sugar, baking powder, and water. During six months of experimental observation, no evidence of greater improvement was registered for the group of children who received the extra milk. F. M. Widdowson and R. A. McCance, who reported on the studies, thus reasonably concluded:

> This was a most valuable experiment because it showed what a good food bread could be for growing children, even when the rest of the diet contained very little milk, animal protein and other protective foods.
>
> The experiments showed firstly that wheat flour had a food value for growing children far beyond that usually assigned to it within recent years. . . Secondly, they made it clear that unenriched white flour was just as valuable a constituent of the diets used at the orphanage as whole wheaten meal.

This evidence clearly demonstrates that wheat bread—even unenriched white wheat bread—is a valuable staple food in mixed diets containing potatoes, other temperate zone vegetables, and a small amount of high quality animal protein. However, it does not warrant the conclusion that wheat flour or bread is a "complete" food, that it could satisfactorily cover as much as 75% of the total calories consumed in other types of diets, that white bread would be as satisfactory as whole wheat products in those diets, or that wheat is a more adequate staple food than the rice, rye, maize, millet and sorghum products commonly used in other parts of the world.

It is pertinent to note that all of the basic cereals are broadly similar in nutrient composition: they all provide abundant calories, offer 8 to 15% of those calories in the form of protein, and also contribute substantial amounts of the various B vitamins and iron along with lesser relative amounts of calcium and other minerals. Moreover, as each of the grains is milled more and more highly to obtain whiter flour or lighter, more highly polished kernels, each suffers heavy losses of its original protein, B vitamins and minerals.

Although the nutrient differences among the various cereals are less marked than the similarities, they



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are too important to be disregarded. Some of these differences favor wheat; others put wheat at a rank lower than one or more of the other major cereals. Currently regarded as among the most important are the differences in protein value. Virtually every type of wheat flour has a higher protein content (i.e., amount of protein as a percentage of total food weight) than representative samples of milled rice; and flours made from "hard" wheats, materially exceed in protein content not only rice, but also all other major cereal products except oatmeal. On the other hand, flours made from the world's more abundant "soft" and "semi-hard" wheats have only slightly, if any, more total protein than has cornmeal, rye flour, pearled barley, sorghum, or most of the common millets.

Equally or more important are the differences in "protein quality" of the various cereals. On this basis, wheat falls considerably in rank, perhaps dropping lower than any of the other cereals except corn. Current "protein quality" ratings are admittedly quite tentative, based largely on limited pioneering research on the amino-acid composition of various foods and amino-acid requirements of human beings. Yet their indications that the biological value of wheat protein is considerably lower than that of rice or of oatmeal are adequately supported by data from feeding experiments.

The higher protein quality of rice and oatmeal—and perhaps also rye flour and some of the millets—does not mean that these are "better foods" than wheat flour. Virtually nowhere in the world is the dominant food staple, whether a cereal or a starchy root or tuber, eaten alone; and the common associated foods may well make up for any serious amino-acid deficiency that exists in the primary staple.

This is most obviously true, of course, in countries like the U.S., where the national diet is unusually varied, the intake of animal protein is unusually high, and even the common wheat bread contains milk solids that alone go far toward compensating for the lysine deficiency of white wheat flour. It is no less true, however, in other countries. Often a very small quantity of animal products or fish, consumed regularly, is sufficient to make good the amino-acid deficiency of the major food staple. In some areas legumes, nuts and other seeds supply the amino-acid(s) most sharply limited in the primary food. Indeed, even such low protein foods as the starchy roots and tubers (generally inferior to any of the cereals as a heavily consumed primary staple) and even leafy vegetables play a significant role as amino-acid balancers. Similarly—and especially noteworthy here—a mixture of two or more cereals may serve the same purpose.

All of this demonstrates conclusively that wheat is a very useful food staple: It is not only a good calorie food, but also a good source of protein and the B vitamins. This is true, though much less true, even of the most highly processed form of wheat—unenriched white flour.

III. Are More Food Calories and Protein Seriously Needed in the Underdeveloped Countries?

The second question is whether large masses of the people in the underdeveloped countries are chronically and seriously in need of more calories and protein (the major nutrients available in wheat). If such a need exists, the obvious implication is that huge numbers of these people are chronically and seriously "undernourished," and perhaps to a degree that means lowered labor productivity.

First, let us agree on what is meant by "serious" need of more calories and protein and by "undernourishment" or "undernutrition." I want to make clear that I am talking here about minimum functional dietary needs or requirements, not about so-called "optimum requirements," nor liberal "recommended allowances," nor the desire for more food or for better food. "Undernourishment" or "undernutrition" refers to the physiological effects of a prolonged, marked deficiency of intake of food calories—effects that include subnormal body weight, with both the degree of deficiency in body weight and also the forms and seriousness of associated symptoms varying with the degree and protraction of the food shortage.

The different degrees and related symptoms of undernutrition have been scientifically investigated and recorded by a University of Minnesota group. Between mild undernutrition, on the one hand, and "semi-starvation," on the other, are differences so enormous that they warrant special emphasis in international discussions of food aid and food trade policies. Mild undernutrition usually does not significantly interfere with the maintenance of life, health, physical activity, or morale of population groups. But at the considerably lower levels of food intake associated with "semi-starvation" (food levels some 25-30% below full requirements) some individuals may be expected to die from starvation and associated illness, and the remaining members of the group will be markedly subnormal in body weight, physically weaker, more prone to disease, less capable of effective work (particularly manual work), perhaps alternately apathetic and irritable, and generally non-social in attitude and action. It is the semi-starvation effects, often referred to as "famine characteristics," which all responsible governments are anxious to abolish from the world.

To what extent do we find such a drastic need of additional food calories in the world today? All experts agree that there are a limited number of local areas where many of the inhabitants suffer from hunger and undernourishment when crops fail in their own district.

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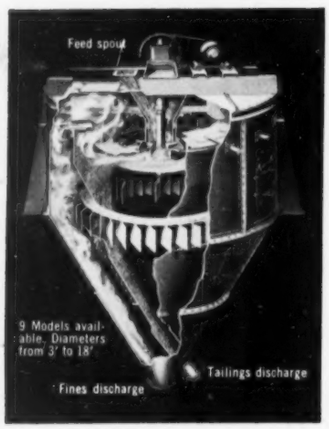

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driest of these areas probably faces famine or semi-famine conditions rather frequently, typically late in the crop year (in the "pre-harvest hunger period"). Such groups of people obviously need additional food calories and protein—not every year, but in commonly recurring periods of seasonal distress. All too often primitive areas of this sort are virtually isolated from outside sources of food supplies because of inadequate communication and transport facilities, which sharply limit, if they do not prevent, timely and effective food relief shipments.

Furthermore, there are occasions of varying degrees of frequency when whole countries suffer extremely heavy crop losses as a result of drouth, widespread floods, or other natural disasters. Here, too, the need for additional food calories and protein is clear. It is equally clear that the magnitude of the need is sometimes so great that an economically underdeveloped country may not be able to finance all of the needed food imports without protracted damage to its national economy.

Under such conditions, any wheat exporting country that offers additional free wheat as "famine relief" to the suffering nation wins general international approval, even from competing exporting countries. Such desirable food relief grants, however, can not be expected to make much impression on our currently excessive wheat stockpile. This is evident from recent American experience. Although the U.S. Congress appropriated large funds to make such needed emergency aid available to friendly foreign governments, and although the U.S. Department of Agriculture has presumably responded promptly to meet all legitimate calls for famine-relief grants and agency-distributed relief donations, the quantity of American wheat actually shipped for this designated purpose over the past four crop years averaged only 22 million bushels annually, with the peak shipments totaling only 32 million bushels. Even if one doubles or triples this figure to allow for probable past inclusion of additional hunger relief shipments under other congressional financing, the total remains unimpressive.

This kind of generally approved "famine relief" aid is obviously not what is meant by politicians and economists who talk hopefully about solving our persisting wheat-surplus production problem by using surplus wheat to "feed the hungry masses and raise labor productivity in the underdeveloped countries." Such phrasing clearly implies notably heavy wheat shipments, continuing over many years if not indefinitely. And it implies a picture of widespread, chronic, weakening undernourishment of large masses of the people in many countries—undernourishment that presumably ranges all the way from something worse than mild undernutrition to semi-starvation. Is this picture of widespread, chronic undernourishment in line with the ascertainable facts?

It is the picture that has been painted by some highly honored staff members of FAO, by a number of respected nutritionists in this country and elsewhere, and by some of the most popular journalists and commentators. For example, Lord John Boyd-Orr, the first director of FAO, declared in 1950: "A lifetime of malnutrition and actual hunger is the lot of at least two-thirds of mankind." Similarly, but less startlingly, a 1956 study of FAO stated:

"Taking a daily food intake of 2,200 calories as an approximate yardstick of the minimum energy requirements needed for preventing undernutrition, FAO estimates for a recent postwar year showed that on average, the consumption of food in countries comprising about one-half of the world population fell below or barely reached this level."

And, more directly, the same 1956 publication categorically commented: "More than one-half of the world population subsists on diets inadequate for health" (i.e. deficient in total calories and/or in one or more other nutrients).

Here and there skeptical voices have been raised in opposition to such alarming statements. And within FAO itself there has been an increasing tendency to say less about calorie-level deficiencies (and to say it more cautiously) and to direct more attention to possible deficiencies of other nutrients, particularly protein.

I do not know—nor does anyone know—what percentage of the world's population stands in chronic need of substantially more food calories or what percentage needs more or better protein. I do not know—nor does anyone know—how such people are distributed among the various countries of the world. I am sure only that the national food supply and food consumption estimates now in existence represent a decidedly inadequate basis for judging and comparing the nutritional status and deficiencies of the populations of individual countries, if for no reason other than that the estimates for many of the underdeveloped countries significantly understate the number of food calories and the amount of protein actually available to those populations.

These negative assertions rest on many years of work with the food production and consumption data of various countries, with differing food

(Turn to ROLE OF WHEAT, page 14a)

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No. 2130—New GrainVayor Model

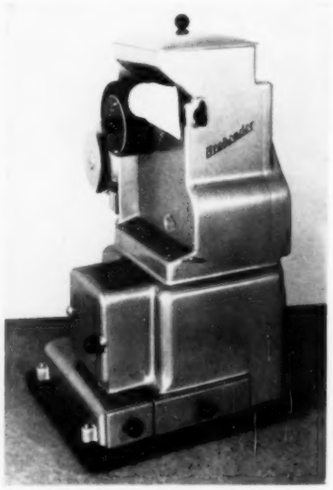
Introduction of a newly designed, high capacity GrainVayor has been announced by the Myers-Sherman Co., manufacturer of portable pneumatic conveying equipment. Grain conveying capacity of the new model has been boosted to 4,000 bu./hr. The conveyor features a new centrifugal compressor that uses a multi-stage fan of 38 in. diameter. It can be operated by one man. The machine also has other uses such as removing dirt, dust, fines, top crust and hot spots. It is designed to load to heights of 150 ft. or more, across distances of 500 ft. or more. More information can be obtained by checking No. 2130 on the coupon.

No. 2131—Protein Analyzer

Hegman, Inc., has announced the availability of the Udy Protein Analyzer which the firm has developed in collaboration with Dr. Doyle Udy. The machine, the firm said, provides a reliable protein count in three and a half minutes. The Udy analyzer is simple to operate and permits country grain buyers, terminals, or millers to make immediate tests for protein instead of waiting hours to days for a laboratory report, the firm said. In operation, a sample of wheat is weighed (approximately 1 gram), placed in a container with a fixed amount of dye, and ground in the React-R-Mill for three minutes, the time being automatically controlled. The sample is then removed from the container and a few drops are tested in the colorimeter which is calibrated to a reference dye sample. The amount of dye bound by the protein in the wheat sample determines the protein content. Check No. 2131 on the coupon for more information.

No. 2132—Pilot Mill

C. W. Brabender Instruments, Inc., has announced the development of a micro-pilot mill which the firm said will give yields of up to 77% depending on wheat and tempering with ash of .6% to .7%. No skilled miller is needed to operate the mill, which is known as the C. W. Brabender Quadruplex pilot mill. The mill has a fixed roll setting for all wheat and a capacity of 100 grams in three minutes. Its dimension is 16 by 19 by 28 in. For more information check No. 2132 on the coupon.



No. 7526—Bin Vibrator Catalog

Publication of a catalog on electric vibrators has been announced by Syntron Co. The 12-page, illustrated booklet gives descriptions, data and specifications for 14 standard vibrators. Also included are illustrations and information on separate vibrator controllers. Typical installations are also illustrated. For copies, check No. 7526 on the coupon and mail.

No. 2135—Bulletin On Crushers

A new bulletin on its Mikro Crushers has been released by the Pulverizing Machinery Division of Metals Disintegrating Co., Inc. Th bulletin points out that Mikro crushers are available in three different sizes and models—the laboratory crusher, the standard crusher and the heavy duty crusher. All three are of the double roll type, designed either to serve as pre-crushers or as independent crushers.

No. 2133—Improved Air-Caddy

The recently introduced mobile Air-Caddy by Ripco, Inc., has already been improved. A more deluxe version with wheel fenders and mounted caddy-vac enables the conveyor to be used for bulk feed and grain loading by vacuum and unloading by pressure. A patented version of tilt-top design permits the conveyor to be lowered over the engine section, thereby reducing the over-all height of the unit in transit. This feature overcomes delivery problems where low entrances, bridges, barn overhangs, etc., make it impossible for larger equipment to make deliveries, the firm said. Dimensions of the conveyor are: Height: 78 in. with caddy-vac tilted over the engine; length from trailer hitch to rear: 108 in.:

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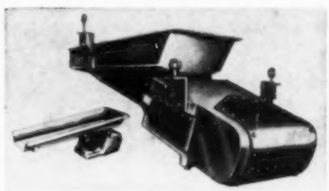
No. 2134—Dust-Tight Magnet Covers

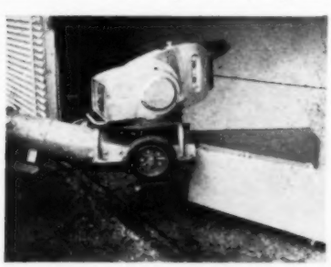
The availability of dust-tight magnet covers for its complete line of electromagnetic vibrating feeders has been announced by the Syntron Co. The innovation is intended to keep the electromagnet dust-free and to decrease maintenance requirements.



The covers consist of rubber gaskets and metal plates which are bolted in place over the openings of the magnet housing. And, because the electromagnet drive contains no wearing mechanical parts to require lubricating or other servicing, the dust-tight covers seldom need to be removed. Obtain more information by checking No. 2134 on the coupon.

No. 7519—Unloading Combination

An unusual flat storage unloading combination was devised by the Seedburo Equipment Co. and the Andrews Machine Co. when a Seedburo Stohr Power Shovel was mounted on an Andrews Model 1000 Portable Auger. The power shovel was placed on the tube directly above the intake of the auger. The capacity of the auger is 9,600 bu. an hour and by pulling grain into the auger hopper with the power shovel, maximum capacity is assured at all times, company literature stated. One man can handle the entire operation; a push-



button on the power shovel handle starts and stops the shovel pulling cycle. The push button must be depressed during pulling cycle; it functions as a "dead man switch" by stopping immediately when released. For details, check No. 7519 on the coupon and mail.

No. 7577—Bulk Fumigant

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into a smaller cylinder mounted on a small truck or trailer for transport to the grain fumigation job. From this fumigation cylinder it is delivered into the building through a meter that reads directly in pounds. The rate of fumigant delivery into the bin is also controllable and can be coordinated with the rate of flow of the air through the grain mass. The new bulk truck, the company says, permits distribution of the Dawson 37 fumigant in a manner somewhat similar to that used for bulk distribution of anhydrous ammonia and liquefied petroleum gas. For further information on the service, check No. 7577 on the coupon and mail.

No. 7575—Automatic Bag Feeder

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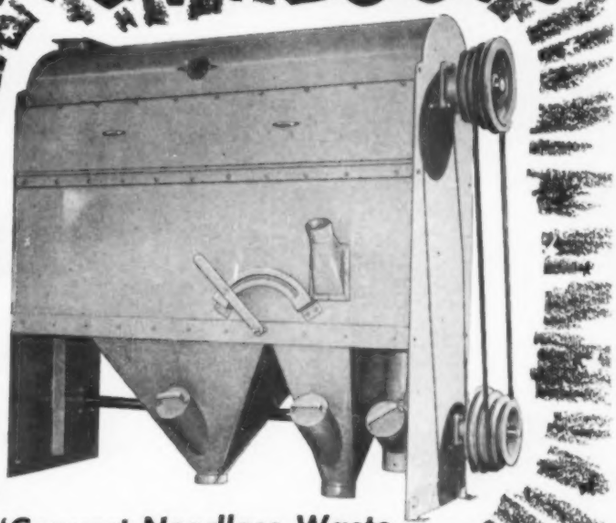

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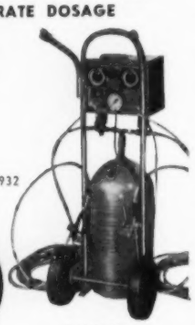

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width and a rear handwheel the bag length. No other adjustments are necessary. The Auto-Mac automatically feeds the bag to the bagholder, which receives a discharge of the product from an overhead scale, thus eliminating manual placement of the bag on the scale bagholder or spout. The filled bag is automatically delivered for closing. The unit has two steel arms with vacuum cups. One arm moves forward to the magazine and draws out one bag from the vertical stack. The second arm moves behind the bag and opens it. Two vertical bars, with air operated clamps, then grasp the opened bag and lift it on the bagholder. The bagholder holds the bag firmly to the spout during filling. All components are timed with one master drive. The company said that the unit obtains maximum efficiency with packing equipment made by Bemis but that it also works well with other scales, usually with only minor adaptations. Further details are available by checking No. 7575 on the coupon and mailing it.

ROLE OF WHEAT

(Continued from page 11a)

composition tables, and with conflicting and changing estimates of the nutrient requirements of population groups. This is, indeed, quite enough to make one skeptical of the meaning and significance of differences as small as 10 to 20% in the per capita food-calorie estimates for different countries. Yet most of the national calorie figures that purportedly show over-all calorie deficiencies — i.e. gross undernourishment — would no longer be classed in the inadequate-calorie group if the current estimates for these countries were increased by 10 to 20%. For other nutrients than calories I should want sharply to raise the percentage figures to which my skepticism applies —to as much as 100% or more for some nutrients in some countries.

Lest you think me unduly skeptical, let me cite some bits of evidence. The FAO State of Food and Agriculture 1957 reported a per capita calorie food-supply estimate for India of 1850 calories as the average for 1953-55. This looks like a threateningly low supply figure. How, then, was it obtained? Its notably low level obviously rests mainly on the official Indian crop figures used in the calculation. Of these, the most important are the estimates for cereals and pulses, which together supply something like three-fourths of the calorie content of the national diet. Consequently, it is noteworthy that a well-designed official sample survey of Indian food-grain consumption in 1949-50, supported by supplementary evidence, suggested that the population actually consumed during that period 20 to 27% more domestic food grain than the official crop estimates indicated was available for consumption. Although similar survey information was not collected for other Indian foods, the probability (based on common experience elsewhere) is that the production of such subsidiary crops was underestimated by a still larger percentage. Thus, even with allowance for the improvement that undoubtedly occurred in Indian crop statistics after 1949-50 (when sample surveys of crop acreage and yields were much less common) it might seem reasonable to raise the FAO calorie estimate for India for 1953-55 by 15-20%. This would put the indicated national food-supply level close to 2,200 calories rather than 1850—an impressive difference.

Let me hasten to say that this demonstrated underestimation of Indian food crops is no reflection on India's statisticians, who are counted among the best in the world. Nor does it mean that India's crop estimates compare unfavorably with those of many other economically underdeveloped countries. Indeed, I should suppose that the reverse is true.

In all underdeveloped countries, the great difficulty and expense of obtaining reliable estimates of agricultural production tend to result in unsatisfactory crop and animal product figures—figures usually too low because of incomplete coverage. Historically, this has been true also in the U.S., Canada, and other more prosperous countries. In 1926 Holbrook Working conclusively demonstrated that the official U.S. wheat production estimates were some 30% too low, on the average, for the decade ending in 1895 and only moderately less understated for the following decade, whereas later estimates showed no such bias. Similar examples of official underestimation of the production of basic foods could be cited for a number of countries in the early or middle stages of development.

Other quantitative uncertainties are encountered in arriving at the estimates of food consumption. For example, it is necessary to deduct from the calculated gross supplies of each reported food some allowance for the quantities wasted and the quantities diverted to non-food uses (such as seed, feed and industrial products). Rarely is there a solid factual basis for making these deductions. Usually the best that can be hoped for are sophisticated guesses; and the sophisticated guesses of different experts may differ by 100, 200, 300% or more. It is noteworthy that even small differences in the conversion or extraction rate used in obtaining estimates of the food calories available from a single primary cereal may well account for differences as large as 30-50 calories per capita per day. For India, this is true of the extraction rate used for polished rice, which is put too low in most Indian food balance sheets.

Finally, many of the national food consumption figures reflect little effort, if any, to cover secondary domestic foods for which official production data are not reported. Such omissions commonly include: (1) Commercial crops of minor economic value; (2) foods grown in home gardens, mainly for family consumption; (3) wild game, including non-commercial and unreported commercial fish; (4) foods collected from wild and semi-cultivated plants; and (5) wine, beer, and other beverages.

There is abundant evidence to show that such omitted food sources are particularly important for many population groups in the less developed countries. For example, F. R. Irvine has listed hundreds of supplementary and emergency food plants eaten in West Africa—foods not taken into account in the usual food consumption calculations for countries in that region. Similarly, an enlightening study of the food habits of a group of Otomi Indians in Mexico showed that pulque (an unfiltered beer made from common cactus) and collected wild green leaves contributed some 13% of the total calories consumed, 11% of the protein, 33% of the riboflavin, roughly a fourth of the niacin, 80% of the Vitamin C, and 17% of the calcium. Such miscellaneous foods, often classified as "weeds", are entirely disregarded in most national food supply calculations.

This and other evidence of the common understatement of national food supplies cast doubt on the validity of assertions that "hundreds of millions of people in the poorer countries are chronically and seriously undernourished," since such assertions, if statistically supported at all, are most frequently based on questionable food supply data.

Even if the supply side of the world food picture were not so sadly unclear and distorted, we still could not determine whether, or to what extent, the inhabitants of various underdeveloped countries suffer from shortages of food calories, protein, or other nutrients. On the demand or need side, there would remain the problem of finding a satisfactory measure of the nutrient requirements of the different population groups. The tentative dietary standards or "allowances" now available (e.g. those of the British Medical Council and the Food and Nutrition Board) are not suitable for this purpose. They refer not to food nutrients at the retail level, but to nutrients actually consumed—in between there is a big, variable, unknown gap representing loss and waste. Moreover, these standards refer not to the minimum nutrient levels believed sufficient to prevent nutritional diseases and to insure ade-

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quate energy for ordinary living and work, but to levels with wide and varying "safety margins" for which little scientific basis exists. Finally, the standards apply to "reference" individuals of European extractions, living in temperate climates under conditions of general economic prosperity; and there is no clear evidence that the same reference figures can be appropriately applied to different races that have lived long in warmer areas at much lower economic levels and/or on very different types of diet.

These basic problems remain, even though the excellent calorie committee of FAO, under Ancel Keys as chairman, has contributed enormously in recent years to improvement of the methods of estimating "safe" calorie allowances for different national populations. The current FAO calorie requirement estimates provide rough practical bases of adjustment for national differences in adult body size, in age and sex structure, and in the average external temperatures to which the various populations are exposed. Fully aware of the roughness of the calorie-adjustment measures indicated, and also of the great uncertainties pertaining to the differing and variable national allowances that should be made for waste, Mr. Keys nevertheless reported optimistically in 1957: "We can . . . estimate with reasonable accuracy the food calories we need to eat, and when we translate this into terms of food production requirements, the result is probably within plus or minus 10% of the true value."

Even if fully safe calorie requirement figures for the poorer countries can now be estimated within 10% of the true figures, this degree of uncertainty remains disturbing for nutritional interpretations, since it must be considered in conjunction with the still greater margins of uncertainty in the production and non-food utilization estimates for such countries.

I conclude, therefore, that the available data on food supplies and nutrient requirements do not afford a satisfactory basis for judging the nutritional status of different nations. Nor do these data, when carefully examined, adequately support the broad generalization, frequently drawn from them, that large concentrated masses of the world's population need considerably more food—more calories—for the maintenance of health and satisfactory labor capacity.

Indeed, the more trustworthy evidence presented in the few well executed dietary-clinical surveys available for underdeveloped countries are generally reassuring as to the basic minimum adequacy of the normal food supplies in those areas. At the Food Research Institute we have tried for years to obtain and study the published results of all reliable dietary-health surveys, wherever made in the world. We have doubtlessly missed some. But our conclusion, based on the records we have seen, is that chronic marked undernutrition with associated adverse health symptoms is rarely encountered as a characteristic of large population groups—that it is mainly to be found among widely scattered, unrepresentative individuals (probably predominantly located in large cities) and to small, unrepresentative, primitive groups whose location, food habits, and cultural patterns are such as to make most of them poor prospects for the utilization of surplus wheat.

Much less uncommon, though by no means typical of the poorer countries, are sizable population groups whose customary calorie intake of food is moderately below any "recommended" level and whose bodies are lean and subnormal in weight, but who nevertheless are clinically judged to be in good health and who appear to pursue their accustomed work without registering unusual fatigue. Such findings seem impossible to explain except on the theory (for which there is much supporting evidence) that human bodies "can adapt to widely different levels of food intake." As Ancel Keys has pointed out, the main elements of adaptability to prolonged shortage of food calories are (1) lower body weight, (2) lower basal metabolism, (3) less energy expenditure, and (4) the use of fewer calories for specific dynamic action (the calorie cost of digesting and metabolizing food, usually estimated at 10% of the calorie intake).

A crucial question is to what extent the lower energy expenditure associated with deficient calorie levels is reflected, if at all, in lower labor productivity. There is no inevitable cause-effect relationship between moderate undernourishment and labor output. Changes in energy expenditure may be reflected in a number of different ways, of which labor output is only one. Mr. Keys has noted that work levels may be sustained or only slightly lowered as calorie levels are reduced, with the associated reduction in physical energy possibly reflected primarily in curtailed off-job activities and secondarily in less violent, less numerous and more efficient muscular movements on the job.

Personally, I believe that basic psychological attitudes and "ways of life" (rooted in unquestioned traditions, feudal concepts, religious influence, lack of education, and extremely limited contacts with enterprising outsiders) have been much more important than food deficiencies in affording indications of low labor productivity in most underdeveloped

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countries. Increased food supplies alone could not be expected to raise labor output significantly in such countries. Yet in recent decades we have witnessed substantial advances in labor output in countries where emphasis has been placed on modification of psychological attitudes, on inspirational imaginative appeals to the young people to do old tasks a new and better way, on provision of more elementary education and technical training, and on the introduction of improved tools and machinery, improved seeds and breeds of livestock, and improved methods and organization of work in both agriculture and industry. It should not be overlooked that what is called "labor productivity" is much less the economic contribution of the raw human agent (dependent on crude physiological capacities) than the result of investment in physical, social, and human capital.

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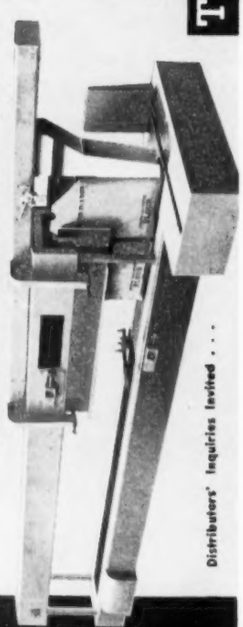

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IV. Protein Needs Specially Considered

"Nutritional status" involves considerably more than calories. However, I have intentionally focused mainly on calories here for several reasons. First, if calories are deficient, the other nutrients can not properly perform their chief functions. For example, if there is a shortage of total calories, protein calories that otherwise would be barely adequate to perform critically needed metabolic functions will be diverted to serve partly as heat and energy producers, thus resulting in possible protein deficiencies. Second, if the total calories are greatly deficient, labor productivity is almost inevitably lowered, whereas this is not true of marked deficiencies of most of the other nutrients. Third, there is general agreement among nutritionists and economists that gross nutritional deficiency diseases attributable to the shortage of other specific nutrients (beriberi, pellagra, scurvy, even kwashiorkor) now affect extremely small percentages of the world's population; and proper selection and preparation of local foods could be counted on to wipe out most of these diseases. Fourth, there is an important economic and international policy reason for stressing calories: If large masses of the people in economically poor countries need and will consume a considerably large quantity of food, carefully distributed gifts and concessional sales of American surplus wheat to those countries are less likely to displace commercial grain exports from other grain-exporting nations.

Despite these good reasons for emphasis on calories, I feel that something more should be said about the possibility of extensive protein deficiencies that might be met through increased consumption of wheat. The problem of human protein requirements has recently received so much international attention, and the link between kwashiorkor and protein consumption has been so much discussed, that many people have come to regard protein deficiency as the world's foremost food problem.

Personally, I doubt that this view will survive a decade of factfinding. Yet it is certainly all to the good that FAO and the World Health Organization have made helpful strides in the direction of understanding and eventually reducing the incidence of kwashiorkor. This disorder, essentially a child's disease, is most common in tropical Africa, though the same syndrome is also prominent in limited sections of Latin America. In markedly affected areas, the incidence varies sharply from one locality to another. Although no generally representative data are available, it would not be surprising to find a common average incidence of something like 10% in large groups of children from 1 to 4 years of age in tropical Africa —a figure in line with the 10.8% average reported for children aged 1-3 in Uganda. As disturbing as such a rate of incidence is, it is not the incidence, but rather the heavy mortality associated with the disease, that makes it so dreaded.

Commonly called "protein malnutrition," kwashiorkor is apparently mainly attributable to fantastically bad weaning and post-weaning diets, found particularly in areas where low protein root crops and bananas play a dominant role in adult diets. In such areas, babies of 12 to 18 months may suddenly be transferred from breast milk to a restricted group of soft, starchy foods like bananas, manioc and sweet potatoes, with limited supplements of cereal gruel.

Ignorance, undesirable tribal customs and taboos are of great importance in determining the prevalence of kwashiorkor. For the children of such vulnerable areas, the chief hope for the future lies in parent education and in better selection and preparation of local foods, not in shipments of foreign wheat. Yet the addition of properly prepared wheat porridge or oatmeal to such diets as well as the substitution of local sorghum and rice gruels for part of the starchy roots now fed, would presumably greatly benefit the children of such countries (countries which are mostly ineligible for concessionally priced American surplus grain because they are either (1) "cash markets" or (2) an integral part of the French Union.) As these areas develop economically and become more easily accessible in the future, domestic and imported grains, pulses, and even animal products seem likely to play a larger role in the diets of both children and adults, probably further reducing the incidence of kwashiorkor and contributing to fuller physical development and perhaps better general health.

It is a tenable hypothesis that in many of the areas where children suffer from kwashiorkor, more protein is also needed by many adults. Here the real need is for more scientific facts, more good dietary-clinical economic surveys that will throw light on how the people eat, live, and work, how their attitudes and cultural patterns affect their food consumption and activities, and to what extent they do or could depend on semicultivated and wild plants as regular or emergency supplements to their diets. In some areas it is clear that pregnant and nursing women, like children, suffer from inadequate protein intake, but no such obvious signs of severe protein deficiency are commonly reported for other adults.

I am sure that in many of the low protein, low calcium food areas, the peoples are notably small in size. And I would assume that if these populations could be fed more better balanced amino-acids, calcium, and associated vitamins (derived primarily, let's say, from mixed grain-pulse diets and green leaves) the children would grow faster to statures higher than their parents. Many nutritionists look with great favor on the development of the "full growth potentialities" of human beings. Perhaps this is important; but I have never seen a fully convincing scientific defense of this view. In raising meat animals, of course, we want full carcass development. This is also desirable, I suppose, for football players and some other athletes. But I see no reason to suppose that in the world, generally, tall people of large frame are any better than short, small-framed people—in health, in disposition, or in intellectual or physical achievement.

Presumably short stature and restricted bone growth are forms of human adaptability to low dietary intake of protein, calcium, and associated nutrients. For adults who have thus adapted to such local diets, it semes reasonable to suppose that increased cereal supplies would do little, if anything, to improve health and/or working capacity. Whether a long time net gain or loss should be expected from foreign assisted supplementary feeding of mixed cereal, and

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perhaps milk to the children of such areas (feeding beyond the quantities needed for prevention of kwashiorkor) would seem to depend partly on the prospects for maintaining a similarly suitable diet in later years. If physiological adaptation to a low protein, low cost diet is essentially necessary and desirable in some poor, unfavored areas, it may well be best to let the adaptation begin early in life. It is quite possible that humanitarian UNICEF or American child-feeding programs in such areas would result in taller, larger-framed children who later, as adults, might suffer considerably more, both physiologically and psychologically, from eating the customary local diets than they would have suffered if their bodies had adapted earlier to such foods. On this question, as on many others, the available scientific knowledge appears to be inadequate, and more research is badly needed.

V. Has U.S. Surplus Wheat Provided "Extra" Foodgrain for the Underfed?

Even if (as here suggested) only very small fractions of the people of the world are so seriously undernourished in an average year that their health and or capacity to work would be significantly improved by the consumption of more wheat, these small fractions would presumably add up to quite a few millions of human beings —not hundreds of millions, nor even tens of millions, but still millions. Since many here are interested in the humanitarian idea of using surplus wheat to raise nutritional status and labor output, it is important to ask whether our recent large exports under Public Law 480 and Mutual Security legislation have been reaching these seriously undernourished individuals.

Presumably well over half of the underfed millions live in Communist China, the Soviet Union, and their satellites—countries whose economic and political systems our government has generally refused to strengthen through free grants or cut rate sales of surplus American foods. Of the remaining underfed people, sizable numbers live in non-communist countries that have not received any of our surplus wheat, either because (1) they were rated as countries financially able to buy commercially at "world prices" all of the wheat their population needed, or (2) their governments or responsible colonial offices deliberately chose not to apply for special American wheat export concessions.

This leaves the specific question whether and to what extent our large surplus wheat exports of 1954 58 have directly added to the food consumption of the remaining smaller group of seriously underfed people in the 40-odd countries annually listed (on the average) as recipients of such "special" concessional exports.

How, in short, has American surplus wheat been distributed within the recipient importing countries? Although the information currently available on this point is undesirably meager, and although country-to-country differences somewhat obscure the general picture, I believe that we can get a fair idea of the situation from the different forms of market distribution that have been characteristically associated with each of the five major "special-export" programs of the U.S. Over the past four crop years, these wheat exports have averaged annually as follows, in million bushels:

Famine-relief (PL 480, II)	13.6
Donations to relief agencies (PL 480, III, Sec. 416)	8.4
Total foreign relief grants	(22.0)
Barter (PL 480, III)	(52.4)
PL 480, Title I	123.7
Mutual Security, Sec. 550-402	57.6
Total foreign currency sales	(181.3)
All "special" export programs	(255.7)

In the absence of evidence to the contrary, we should probably assume that most of the 22 million bushels annually supplied for relief purposes (and shipped mainly to Asiatic countries, Yugoslavia, and, surprisingly, Italy) went directly to aid people who otherwise might have been undernourished—at least slightly to moderately, if not seriously undernourished. We can reasonably credit repeated reports that some of these people sold the relief wheat they received on regular commercial or black markets. If so, and if they were hungry, they presumably then bought cheaper foods and other desired goods for their own consumption. Such action probably somewhat reduced the demand for commercial wheat imports (if that was not already at the maximum authorized by the respective national government) and somewhat strengthened the commercial demand for coarser grains of domestic and foreign origin; but it nevertheless contributed to increased consumption of food by the needy recipients.

In contrast, the bulk of the American "barter" exports went directly into commercial channels mainly in Western European countries and Japan—countries which presumably otherwise would have imported virtually equivalent amounts of wheat on ordinary commercial terms. The "barter" wheat thus contributed almost nothing to the undernourished people of the recipient countries and added little, if anything, to world grain consumption.

Over twice as large as the barter shipments and relief grants, combined, were the sales of surplus wheat made under special governmental agreements. These permitted payment in the domestic currencies of the recipient countries and pro-

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Collectively these companies are known as the "Mill Mutuals" and compose the Association of Mill and Elevator Mutual Insurance Companies, which operates the Mill Mutual Fire Prevention Bureau, and Departmental Offices of the Mills Mutuals as follows:

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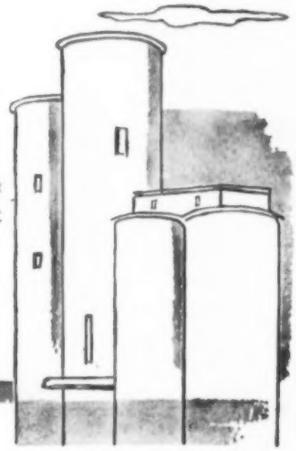
OHIO DEPARTMENT, COLUMBUS;
PACIFIC DEPARTMENT, SEATTLE.



In addition to their fieldmen, to serve you in the laboratory and in the field are the engineers of Mill Mutual Fire Prevention Bureau, 400 West Madison Street, Chicago.

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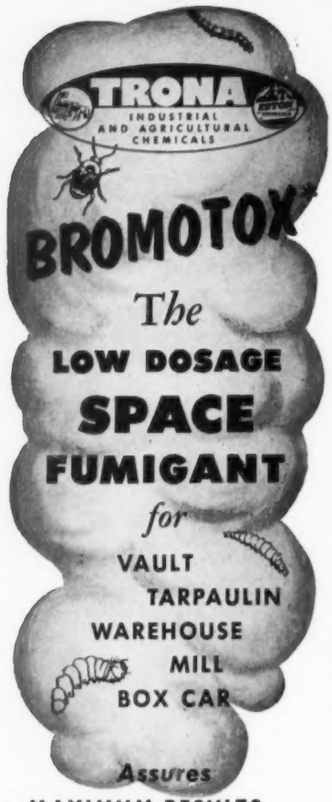

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vided that variable major portions of the currency payments would be returned to the purchasing governments as economic-development loans carrying concessionally low interest rates. Although a small amount of the wheat thus sold was used for special group-feeding programs, the great bulk of these exports was channeled to consumers in the importing countries through ordinary commercial markets at standard commercial prices. Consequently, this wheat was purchased mainly by regular wheat consumers, not by undernourished, low income people. In so far as the latter benefited at all (and they presumably did in a number of the recipient countries) they benefited indirectly (1) through the increased grain supplies and resulting lower coarse grain prices, and (2) through the increased employment opportunities made possible by expanded government investment programs with which domestic currency loans were or later would be associated.

Only a country-by-country analysis of the Mutual Security and PL 480 Title I wheat sales and agreements would afford even the roughest basis for estimating what portion of these wheat exports contributed in some way to increased grain consumption and what portion did not. At best, however, it seems probable that these two programs, and also all of our "special" wheat export programs combined, had a very limited effect in improving the nutritional well-being and labor capacities of the seriously undernourished people in the recipient countries. Even this modest contribution must be set against the possible injury suffered by farmers of other grain exporting countries through loss of import markets supplied by the heavily subsidized, concessionally priced American wheat.

Conclusions

Let me briefly state the primary conclusions that can be drawn from the preceding discussion.

First, the available evidence, critically examined, does not support the presumption that there are hundreds of millions or even tens of millions of seriously undernourished people in the world whose health and labor productivity would be markedly improved by the consumption of additional grain. The most trustworthy evidence rather suggests that the percentage of people seriously undernourished is extremely small. Moreover, a major fraction of these underfed people are so distributed geographically and culturally that they do not offer a promising outlet for surplus American wheat. Although lesser degrees of undernourishment, not reflected in obviously lower levels of health or labor output, are more commonly found in low income areas, it appears hard to justify heavily subsidized, concessionally priced exports of American wheat to those areas on nutritional grounds alone, especially in view of the many difficulties of distributing such wheat (or its equivalent) to sizeable numbers of widely scattered, needy individuals. In the poorer countries, where wages are typically low and organized charity is virtually non-existent, it is much easier to talk idealistically about "feeding the hungry" than it is to do so wisely and effectively.

Second, wheat has a notably high nutritional value as a basic food—higher, indeed, than was generally recognized prior to the Wuppertal experiments in feeding undernourished German children after World War II. Yet wheat is apparently not a "better food" than rice, nor even than some of the cheaper, coarser grains that can more appropriately be purchased by undernourished, low income groups.

Third, American foreign relief grants of wheat, averaging some 20 million bushels annually during 1954-58, presumably increased food consumption in the recipient countries and helped to relieve or prevent undernourishment. In contrast, the great bulk of our concessionally priced wheat exports in those years was channeled into commercial markets of the recipient countries and was sold at regular commercial prices to ordinary wheat consumers. Any nutritional benefit such exports gave to poor, undernourished groups was indirect and decidedly limited.

Fourth, although we might look forward to future moderate increase of legitimate "famine relief" grants for supervised distribution to vulnerable, undernourished individuals in various low income countries, the total quantity of surplus wheat required annually for such assistance will necessarily remain small. A mere 2 million bushels of wheat will provide an additional 500 calories per capita per day for a whole year to 1 million undernourished people.

Fifth, if there is any substance to the hope for large future exports of American wheat, it must presumably be found not in proposals to "feed the undernourished masses of the world," but in marked downward adjustment of American import barriers, and in wise, internationally coordinated and supported plans for economic development of the low income countries. As a carefully planned adjunct of, but not substitute for, expanded American dollar aid, substantial exports of surplus American wheat could well be counted on to contribute significantly to some development programs. Here, however, two crucial questions immediately arise: (1) What national safeguards can be introduced to prevent the recipient low income countries from becoming and remaining too dependent on heavily subsidized imports of American grain—a dependence that could extend to the point of preventing needed expansion of their domestic grain production? (2) What international safeguards can be set up to prevent the heavily subsidized, concessional American exports from adversely and unfairly affecting the non-subsidized commercial exports of other grain-exporting countries—countries whose farmers depend for their living on unsubsidized production and exportation of wheat, rice, barley, corn and other foods? These are problems of international concern that pose the need for active international consultation, co-operation, and perhaps limited supervision, with the international pressures aimed partly at gradual reduction of all national export subsidies.

Sixth, for the more distant future, the hope for American export wheat lies in the expansion of unsubsidized, low-priced, commercial sales of wheat, produced at low cost by efficient American farmers left free to manage their crop plantings and marketings as they wish. Throughout the world, wheat and rice are the two preferred food cereals. They will be purchased wherever and whenever people can afford to buy them. Low-priced, unsubsidized, commercial export wheat can thus fairly win increasing markets in the rapidly growing low-income countries as economic development pushes up productivity and mass purchasing power. Such low-priced commercial wheat will also flow increasingly to foreign feed grain markets, supported by a rising world demand for animal products. In short, the more distant—and perhaps not too distant—hope for heavy North American wheat exports lies in the realm of food preferences, not food deficiencies.

FUMIGATION

(Continued from page 3a)

the aeration fan outlet and the space above the grain so that every fumigation could be a recirculation fumigation that assures even distribution of the fumigant vapors in the grain mass; thus assuring an even and effective insect kill in all parts of the grain. A plastic coated, high tensile strength cloth was used to make a collapsible plenum chamber to be tightly strapped over the fan outlet. A similar chamber, or cover, has been developed to fit over the roof ventilator or other roof opening normally found in these bins. A round arm extending from each plenum chamber is then attached to a collapsible plastic tube with an adaptation of the hula-hoop with which the children have been having so much fun in recent years. A whole hula-hoop, just the right size to fit inside the plastic tube, is sewed within the tube and a half hula-hoop with a clamp on it is clamped over the top of it so that one plastic tube can be held in contact and coupled with a second plastic tube. This makes it possible to pass the gas-air mixture through the grain a number of times and to make essentially all fumigation of flat storage a recirculation fumigation.

Custom fumigators throughout the major grain storage areas in the U.S. are preparing to make this system of application available to grain storage operators in 1959. It is believed by Ferguson officials that an improved fumigant composition, combined with a new system of bulk distribution and bulk delivery into the bin at controlled rate of delivery, plus portable, collapsible recirculation equipment will result in improved and more dependable fumigation results in the 1959 season.

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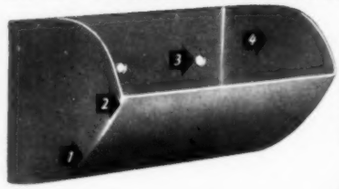

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